Rock Lake
Aquatic Vegetation Management Plan

February 28, 2005

Prepared for:
Rock Lake Conservation Club
3701 Ironwood Way
Anderson, Indiana 46011

Prepared by:
Nathan Long
Aquatic Control, Inc.
PO Box 100
Seymour, Indiana 47274

Executive Summary

Aquatic Control was contracted by the Rock Lake Conservation Club to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Rock Lake Conservation Club and the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. The primary nuisance species within Rock Lake is the exotic plant Eurasian watermilfoil (*Myriophyllum spicatum)*. This species was introduced into the U.S. from Europe. The negative impact of this species on native aquatic vegetation, fish populations, water quality, and other factors is well documented and will be discussed in further detail. White water lily is also abundant in Rock Lake and can create nuisance situations around dock areas. The primary recommendation for plant control within Rock Lake includes the use of Renovate herbicide to selectively control Eurasian watermilfoil throughout the lake. If the action plan is initiated a noticeable reduction and possible elimination of Eurasian watermilfoil should occur in one to three years. In response to the reduction in Eurasian watermilfoil, an increase in native species abundance should take place. Abundant white water lily (*Nuphaea tuberosa*) and spatterdock (*Nuphar spp*.) beds should be protected, however, these species should be closely monitored. If these species create nuisance conditions, individual property owners should take responsibility for managing the legal 625 square foot area. This can be accomplished through physical removal or small-scale herbicide applications.

Acknowledgements

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Indiana Department of Natural Resources – Division of Soil Conservation and the Rock Lake Conservation Club. Aquatic Control Inc completed the field work, data processing, and map generation. Identification and verification of some plant specimens was provided by Dr. Robin Scribailo of Purdue University North Central. Special thanks are due to Mr. Bob Ward and Mr. Ed Hornung of the Rock Lake Conservation Club for his help in initiating and completing this project. Special thanks are given to Ed Braun and Jed Pearson with the Indiana Department of Natural Resources – Division of Fish and Wildlife for their assistance on this project. Special thanks are given to Cecil Rich of the Indiana Department of Natural Resources for his review of this project. Author of this report is Nathan Long of Aquatic Control. The author would like to acknowledge the valuable input from David Isaacs, Brian Isaacs, Joey Leach, Barbie Huber, and Steve Lee of Aquatic Control for their field assistance, map generation, review, and editing of this report.

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Introduction

Aquatic Control was contracted by the Rock Lake Conservation Club to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

The aquatic vegetation management goals of the Rock Lake Conservation Club are as follows:

1. Maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.
2. Direct efforts to controlling the negative impacts of aquatic invasive species.
3. Provide reasonable public recreational access while minimizing the negative impacts on fish and wildlife.

Eurasian watermilfoil is the primary nuisance exotic species in Rock Lake. This species was first documented in Rock Lake by district fisheries biologist Ed Braun during a 1997 fish survey. The primary recommendation from the 1997 Fish Survey Report was for the Rock Lake Conservation Club to work with a licensed applicator to develop a vegetation management plan that will eliminate or at least limit Eurasian watermilfoil and promote native plant species (Braun, 1998). The Rock Lake Conservation Club also desired control of Eurasian watermilfoil in order to improve boat access, navigation, and the overall aesthetics of the lake. Funds were collected and made available for treatment of a 60-foot band within developed shoreline areas. Acceptable control of this species was achieved in this area with annual treatment of 2,4-D herbicide. However, Eurasian watermilfoil remains outside the treatment area and 2,4-D has never completely eliminated this species from the treatment zone. The Rock Lake Conservation Club contracted Aquatic Control Inc. to complete this plan in order to more accurately document the plant community within Rock Lake and obtain funding to more aggressively pursue Eurasian watermilfoil in an attempt to eliminate it from the lake and prevent it’s spread to other lakes in the area.

Watershed and Water Body Characteristics

Rock Lake is a 56-acre natural lake located on the border of southwest Kosciusko and northeast Fulton County in North-Central Indiana (Figure 1). Rock Lake is relatively shallow with an average depth of approximately six feet and a maximum depth of thirteen feet. Public access is limited to an easement on the east side of the lake. The primary inlets to Rock Lake are Landis Ditch and Lautzenhizer Ditch located in the Southeast corner of the lake. The outlet of Rock Lake is located in the northern part of the lake and is the headwater’s Chippewanuck Creek. A depth control structure for Rock Lake is located at the mouth of Chippewanuck Creek. The majority of Rock Lake's watershed is used for agricultural purposes, including cropland, pasture, and agricultural woodlots. This type of watershed is typical of Kosciusko and Fulton counties. Approximately 40% of the shoreline is developed for residential use. The remaining 60% of the shoreline is dominated by emergent wetland vegetation.

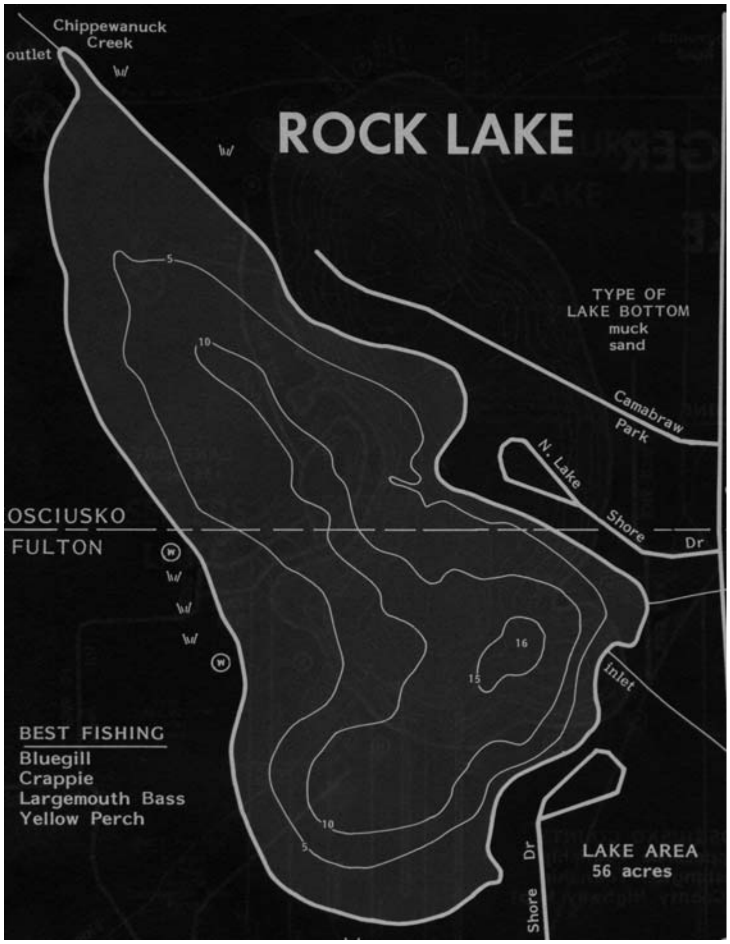

Figure 1. Bathymetric Map of Rock Lake (Bright Spot Maps, 1996)

Rock Lake has a watershed that is conducive to siltation and high phosphorus loading. This can lead to nuisance algae blooms, increased shallow areas, and an overall degradation of water quality. No diagnostic watershed studies have been conducted for Rock Lake and this type of study is beyond the scope of this plan. Initiation of this type of study should be considered in the near future. However, improvement of the watershed and reduction in phosphorus loading will not control nuisance vegetation. Typically, as watersheds are improved, water clarity will increase. This in turn will increase light penetration and allow for vegetation to grow in deeper water. Submersed vegetation obtains the majority of necessary nutrients from the sediment. The Department of Fisheries and Aquatic Sciences at the University of Florida recently conducted a study comparing the amount of available nutrients to plant growth. They sampled aquatic plants in 319 lakes between 1983 and 1999 and found no significant relationship between nutrients in lake water and the abundance of aquatic plants (Bachman et. al., 2002).

Fisheries

The latest fish survey on Rock Lake was completed on June 23 & 24, 1997 by the Indiana Department of Natural Resources. Sampling effort was 55 minutes of night dc electrofishing, three trap-net lifts, and three gill-net lifts. A total of 674 fish and 18 species were collected (Table 1). Bluegill (*Lepomis macrochirus*) was the most abundant species collected, followed by gizzard shad (*Dorosoma cepedianum*), largemouth bass (*Micropterus salmoides*), golden shiner (*Notemigonus crysoleucas*), spotted gar (*Lepisosteus oculatus*), brown bullhead (*Ameiurus nebulosus*), yellow perch (*Perca flavescens*), white crappie (*Pomoxis annularis*), longear sunfish (*Lepomis megalotis*), yellow bullhead (*Ameiurus natalis*), carp (*Cyprinus carpio*), warmouth (*Lepomis gulosus*), pumpkinseed (*Lepomis gibbosus*), white sucker (*Catostomus commersoni*), spotted sucker (*Minytrema melanops*), black crappie (*Pomoxis nigromaculatus*), black bullhead (*Ameiurus melas*), and channel catfish (*Ictalurus punctatus*). The fish population was determined to provide satisfactory fishing. Bluegill were numerous and larger than they were in the 1977 survey. No largemouth bass over 14.5 inches were collected and growth was slow for older bass. Growth of bluegill, crappie, and perch was better than in 1977. Spotted gar was also collected and is a component of the predator population. Both white and black crappie were collected, but numbers were significantly lower than in 1997. Yellow perch were slightly less abundant in 1997, but they were larger and growth was faster. The primary recommendation of the fish survey was to form an aquatic vegetation management plan and attempt to eliminate or at least reduce Eurasian watermilfoil abundance (Braun 1998).

Table 1. Fish collected from Rock Lake, June 23-24, 1997.

Species	Number Collected	Percent
Bluegill	371	55.0
Gizzard shad	63	9.3
Largemouth bass	59	8.8
Golden shiner	28	4.2
Spotted gar	26	3.9
Brown bullhead	25	3.7
Yellow perch	24	3.6
White crappie	19	2.8
Longear sunfish	9	1.3
Yellow bullhead	9	1.3
Carp	8	1.2
Warmouth	6	0.9
Pumpkinseed	6	0.9
White sucker	6	0.9
Spotted gar	5	0.7
Black crappie	5	0.7
Black bullhead	4	0.6
Channel catfish	1	0.1

Present Water Body Uses

Approximately 30 homes line the shore and channels of Rock Lake (Figure 2). The majority of the residents have docks and/or swimming areas in front of their residences. During the summer months, many of the residents enjoy fishing and swimming near their homes. Dense Eurasian watermilfoil beds have hampered these activities in the past. Eurasian watermilfoil has also impacted boating activities. Rock Lake has an electric motor only restriction in place, so water skiing and jet skiing does not take place. However, most residents own boats with electric motors. Dense Eurasian watermilfoil beds are difficult to navigate with electric motors.

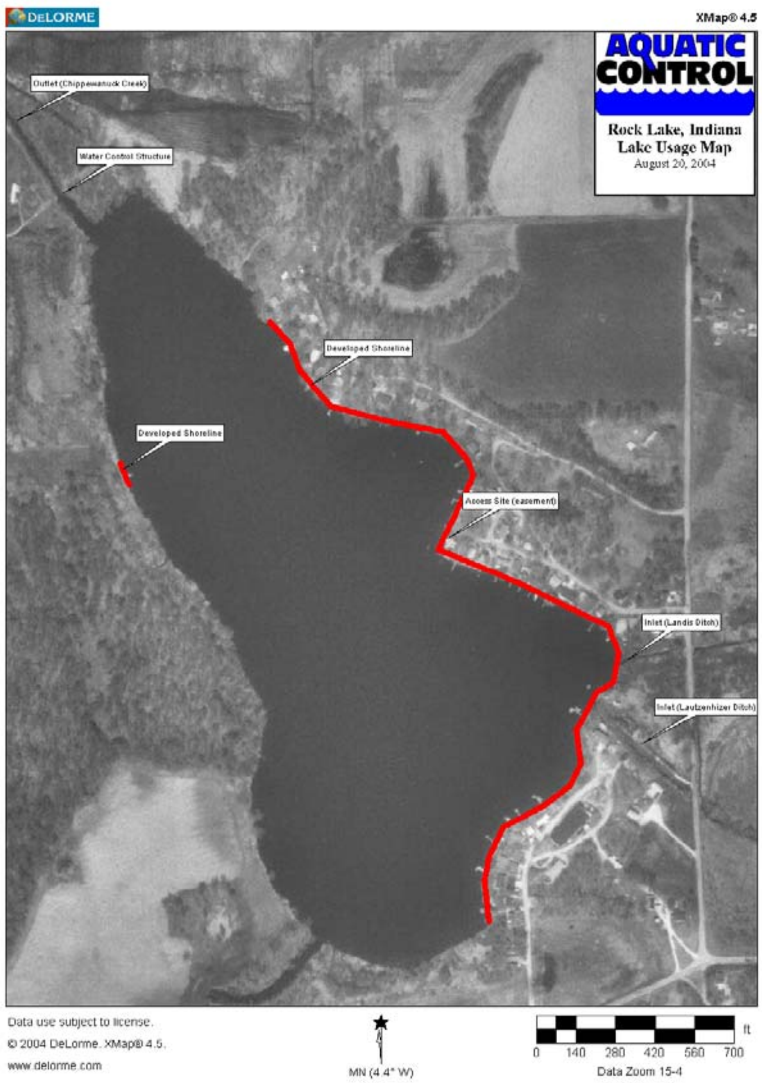

Figure 2. Lake Usage Map (not to scale see appendix)

Aquatic Plant Community

Past aquatic plant sampling on Rock Lake has been limited to visual observation. Braun found abundant vegetation in Rock Lake during the 1997 fish survey. He also found lush beds of water lilies and spatterdock along undeveloped shoreline. He noted the dominant submersed vegetation was Eurasian watermilfoil, which was thick to depth of over ten feet (Braun, 1998).

On May 25, 2004, Aquatic Control conducted sampling prior to treatment in two areas of Rock Lake (Figure 3). Spatterdock and Eurasian watermilfoil each comprised 30% of the plant community in treatment area 1. Horned pondweed (*Zannichellia palustris*) (20%), white water lily (15%) and coontail (*Ceratophyllum demersum*) (5%) were also present. Spatterdock was the dominant species in treatment area 2 (45%), followed by Eurasian watermilfoil (20%), white water lily (20%), and horned pondweed (15%).

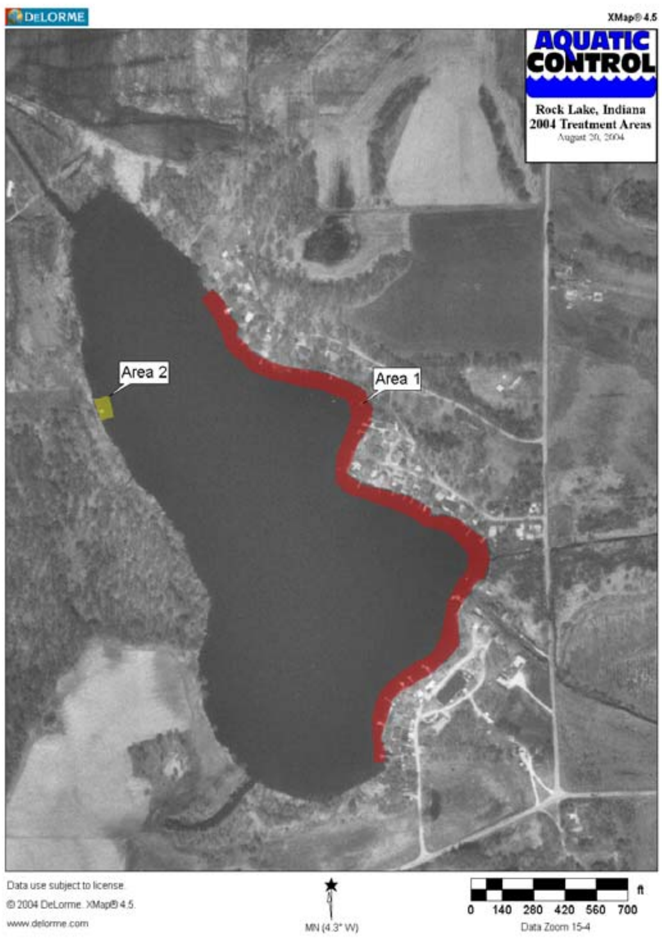

Figure 3. Rock Lake, May 25, 2004 treatment and sampling areas (not to scale see appendix)

Tier I and Tier II sampling was completed on Rock Lake on August 20, 2004. Ideally, two Tier II surveys should be completed in a season in order to document changes in plant community characteristics that occur over the course of the spring through late summer season, but due to time limitations a single survey was completed in 2004.

Tier I Survey

The Tier I survey was developed to serve as a qualitative surveying mechanism for aquatic plants. The Tier I survey is based upon the procedure manual developed by Shuler & Hoffmann, 2002. This survey will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody (DNR, 2004)

The Tier I survey revealed two distinct plant beds within Rock Lake totaling 20.77 acres. (Table 2 & Figure 4). Plant bed 1 was determined to be 5.53 acres. The substrate of plant bed 1 was gravel and rock. A total of six species were observed within the plant bed. Sago pondweed (*Potamogeton pectinatus*)was the dominant plant species (21-60% abundance), followed by Eurasian watermilfoil, white water lily, and spatterdock (2-20%). American water willow (*Justica Americana*) and coontail were also present in plant bed 1 (<2%). Less than 20% of plant bed one contained plants that reached the surface and created a canopy. Eurasian watermilfoil historically has been the dominant species in this area based upon past visual observations. However, 2,4-D was applied in June and has reduced the coverage of this species allowing sago pondweed to become dominant at the time of the survey.

Table 2. Tier 1 Survey Results

Plant Bed I.D.	**#01**	**#02**
Size (acres)	**5.53**	**15.24**
	Abundance Rating*	**Abundance Rating***
Eurasian Watermilfoil	2	1
Sago Pondweed	3	3
White Water Lily	2	4
Coontail	1	1
American Water Willow	1	-
Spatterdock	2	1

*Rating is scored from 1 to 4 with 1 being least abundant and 4 being most abundant

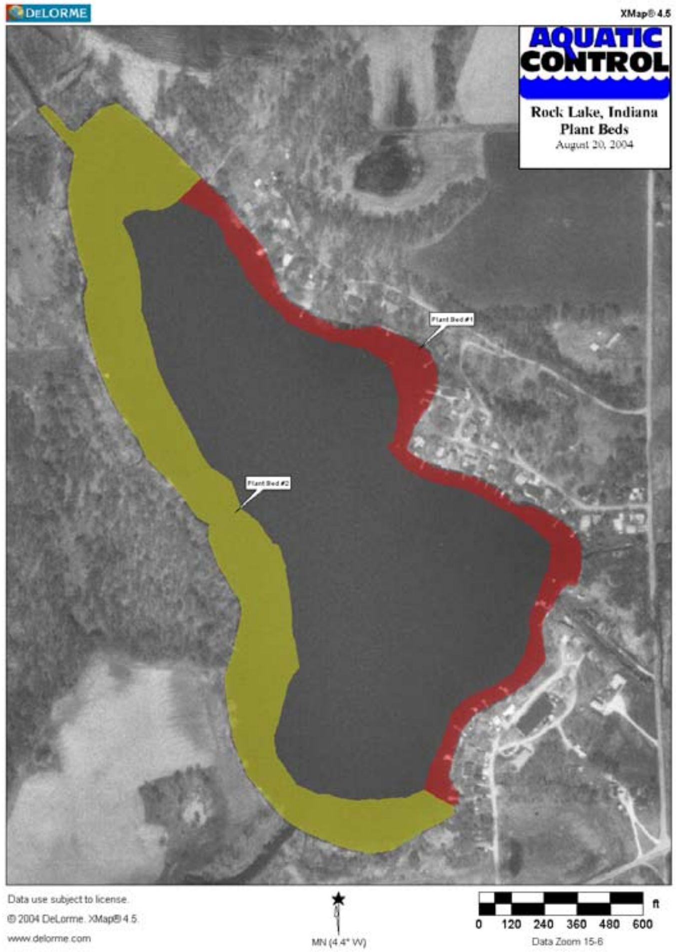

Figure 4. Tier I Plant Beds, Rock Lake, August 20, 2004 (not to scale see appendix)

Plant bed 2 was determined to be 15.24 acres (Figure 4). The substrate of plant bed 2 was gravel and rock. A total of five species were observed within the plant bed. White water lily was the dominant species (>60%) followed by sago pondweed (21-60%). Eurasian watermilfoil, coontail, and spatterdock were also observed (<2%). Greater than 60% of the plant bed was dominated by canopy forming plants (white water lily).

Tier II Survey

Creation of the aquatic vegetation management plan also requires sampling to quantify the occurrence, distribution, and abundance of aquatic vegetation. This type of survey will be referred to as the Tier II survey. This protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation
2. to compare present distribution and abundance with past distribution and abundance within select areas (DNR, 2004).

All of the data which was collected through the use of this protocol was recorded on standardized data sheets. The data collected was compared to data collected by district fisheries biologist Jed Pearson, which is presented in his 2004 paper “A Sampling Method to Assess Occurrence, Abundance, and Distribution of Submersed Aquatic Plants in Indiana Lakes”. In this paper, Pearson used 21 northern Indiana lakes to calculate various aquatic plant abundance and diversity metrics. We used the same sampling procedure outlined in Pearson’s paper to calculate these same metrics for Rock Lake (the data collected in Pearson’s report will be referred to as “Indiana average”). The data collected will also be valuable for future comparison, which will document changes in the plant community following proposed management activities.

Sample sites were randomly selected throughout the littoral zone (number of sites is pre-determined and based on lake size). Once a site was reached the boat was slowed to a stop and the coordinates were recorded on a hand-held GPS unit and later downloaded into a mapping program. A depth measurement was taken by dropping a two-headed standard sampling rake that was attached to a rope marked off in 1-foot increments (Figure 5). An additional ten feet of rope was released and the boat was reversed at minimum operating speed for a distance of ten feet. Once the rake is retrieved the overall plant abundance on the rake is scored from 1-5 and then individual species are placed back on the rake and scored separately (the rake is marked off in 5 equal section on the tines).

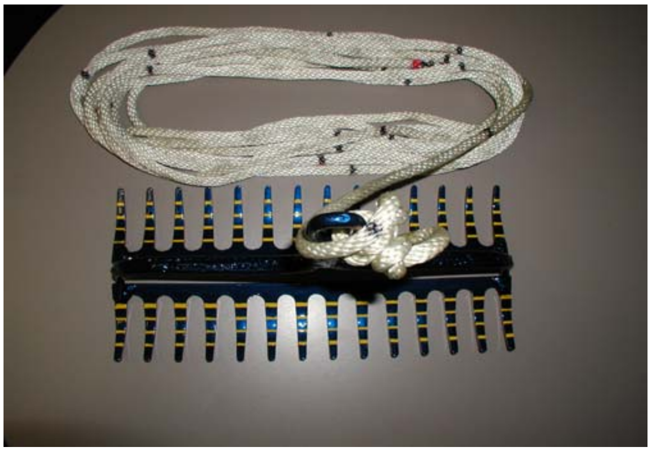

Figure 5. Sampling Rake

Tier II sampling took place on August 20, 2004 immediately following Tier I sampling. A secchi disk reading was taken prior to sampling and was found to be 2 feet. Forty sites were selected within the littoral zone (Figure 6). Site location was skewed to areas with less floating vegetation (the western side of Rock Lake was dominated by spatterdock and white water lily beds and this type of sampling is not designed for floating vegetation). Plants were present to a maximum depth of five feet. The mean depth from which samples were taken was 2.73 feet. The mean rake density score for Rock Lake was 1.58. Species richness (average number of species per site) was 0.98 for all species and 0.70 for natives only. This was below the Indiana average calculated from Pearson’s data. Site species diversity index was 0.74 for all species and 0.66 for native species only. Rock Lake had a rake diversity score of 0.70 for all species and 0.59 for natives only (Table 3). Figure 7 illustrates overall distribution and abundance of aquatic vegetation.

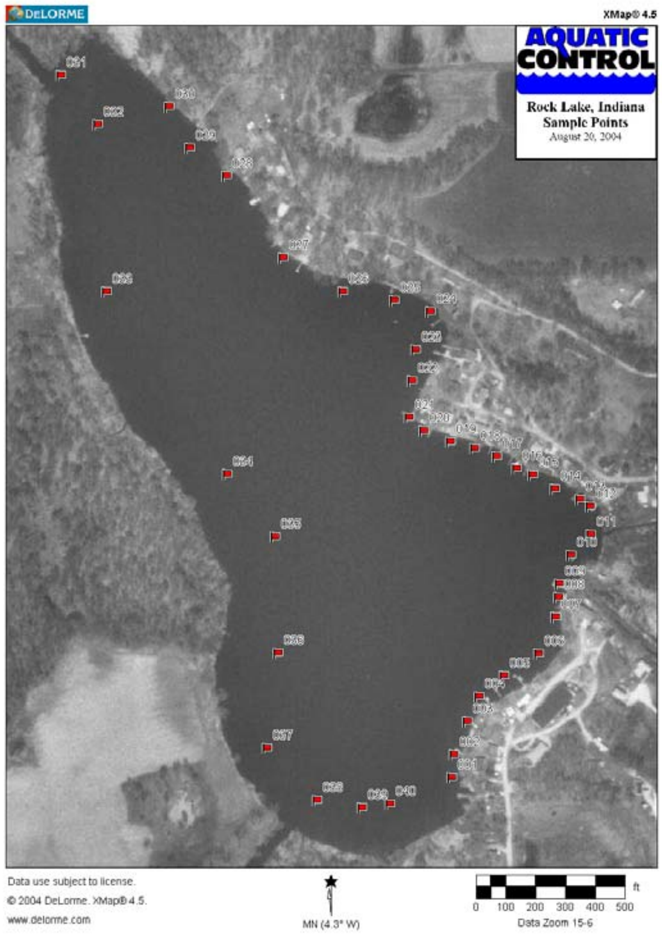

Figure 6. Tier II Sample Points (not to scale see appendix)

Table 3. Rock Lake vegetation abundance, density, and diversity metrics compared to average

	Rock Lake*	Indiana Average**
Percentage of littoral sites with plants	65%	-
# of species collected	5	8
# of native species collected	4	7
Mean Rake Density	1.58	3.30
Rake Diversity (SDI)	0.7	0.62
Native Rake Diversity (SDI)	0.59	0.50
Species Richness (Avg # spec./site)	0.65	1.61
Native Species Richness	0.38	1.33
Site Species Diversity	0.74	0.66
Site Species native diversity	0.66	0.56

*(standard deviation not included)
**Figured from Pearson's 2003 survey of 21 Northern Indiana Lakes

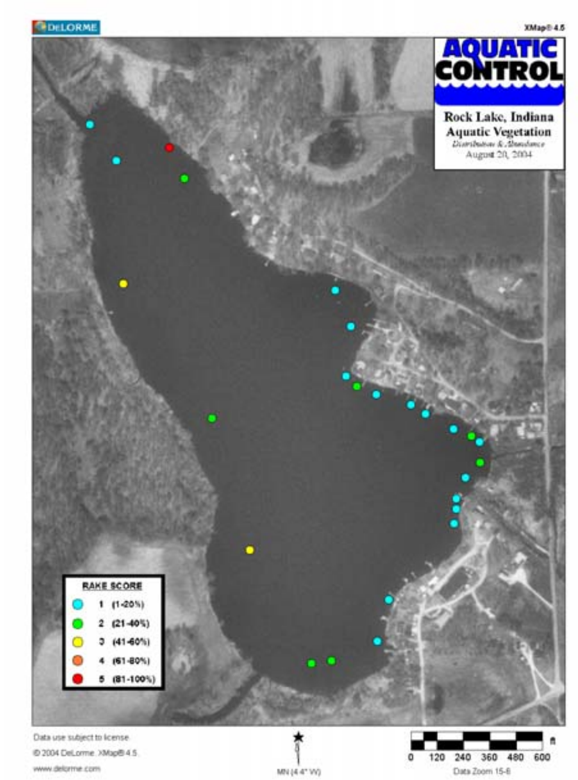

Figure 7. Aquatic vegetation distribution and abundance (not to scale see appendix)

The Tier II survey also allows for analysis of individual species distribution and abundance (Table 4). A total of five species were collected of which four of the species were natives. Eurasian watermilfoil was the only exotic species collected. White water lily was present in the highest percentage of sample sites (32.5%) (Figure 8), followed by Eurasian watermilfoil (27.5%) (Figure 9), sago pondweed (20%) (Figure 10), coontail (15%) (Figure 11), and spatterdock occurred at a single site. The Tier II survey is designed to sample submersed vegetation, but in Rock Lake much of the littoral zone is dominated by rooted-floating species. The sampling is not designed for this type of plant, however these species were present on rake tosses and have been included in the sampling data.

Table 4. Species collected during Tier II sampling.

Common Name	Scientific Name	Frequency of Occurrence	Relative Density*	Dominance Index**
White Water Lily	*Nymphaea tuberosa*	32.5	0.63	12.5
Eurasian Watermilfoil	*Myriophyllum spicatum*	27.5	0.28	5.5
Sago Pondweed	*Potamogeton pectinatus*	20.0	0.23	4.5
Coontail	*Ceratophyllum demersum*	15.0	0.18	3.5
Spatterdock	*Nuphar variegetum*	2.5	0.05	1.0

*Mean rake score at all sites
**Percent of maximum abundance

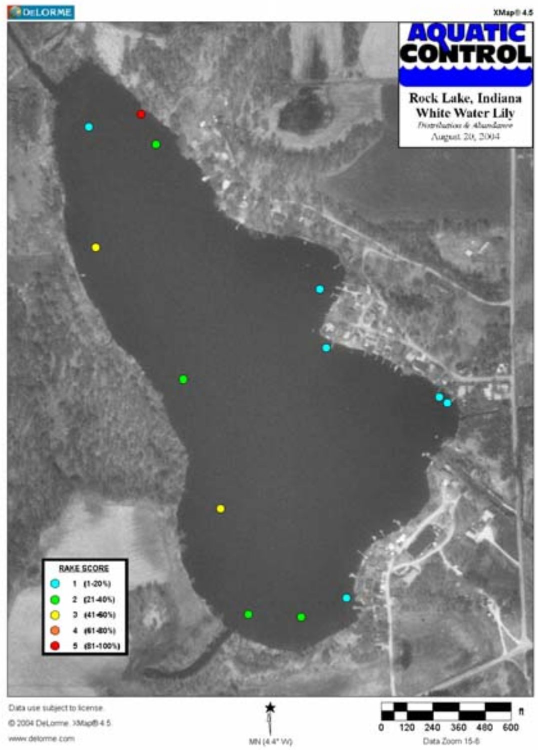

Figure 8. White water lily distribution and abundance (not to scale see appendix)

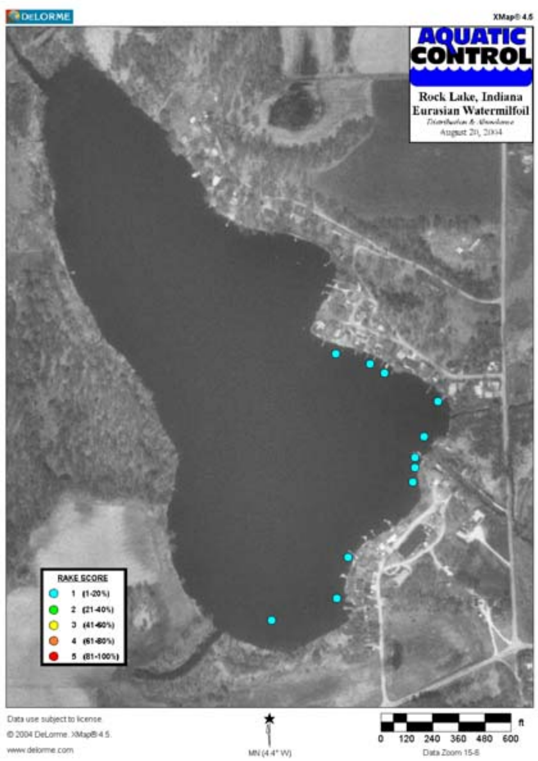

Figure 9. Eurasian watermilfoil distribution and abundance (not to scale see appendix)

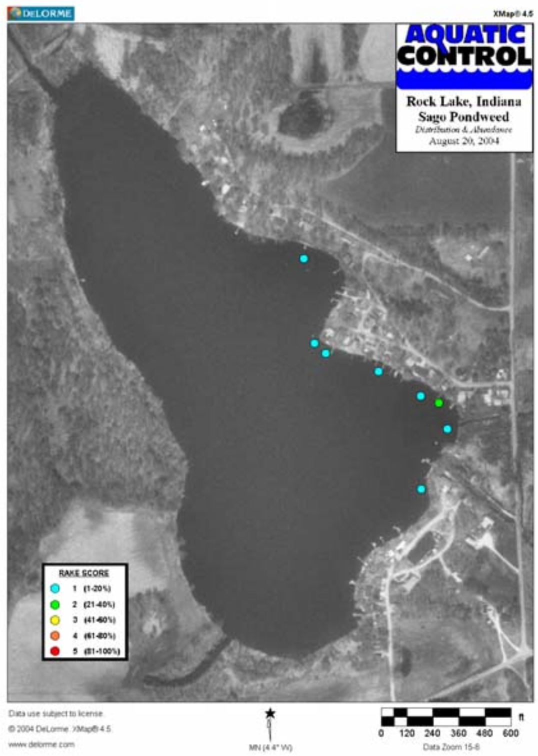

Figure 10. Sago pondweed distribution and abundance (not to scale see appendix)

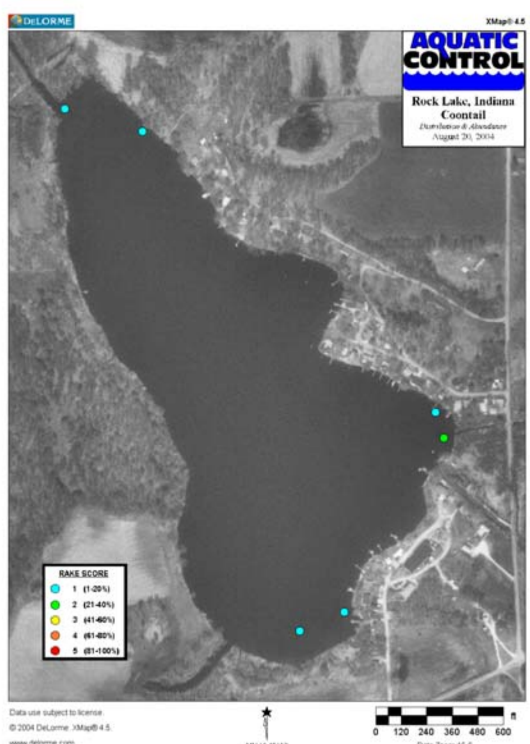

Figure 11. Coontail distribution and abundance (not to scale see appendix)

Plant Management History

Following the 1997 IDNR fish survey, the Rock Lake Conservation Club followed the recommendation of district fisheries biologist Ed Braun and initiated treatment of Eurasian watermilfoil. Enough funds were raised and a permit was approved for treatment of 7.5 acres of Eurasian watermilfoil beds around developed areas of the shoreline. The average treatment width was 60 feet out from shore. Along with the Eurasian watermilfoil treatment, 0.5 acres of spatterdock was approved and treated in order to keep a boating lane open into Chippewanuck Creek. This same treatment was completed again in 2000 and 2002. There was no treatment activity in 2001. In 2003, treatment of spatterdock and white water lily was not permitted, but the Eurasian watermilfoil treatment was approved and completed in that year using 2,4-D herbicide. Milfoil was again treated in the same area in 2004. Treatment of spatterdock and/or water lilies was not approved in 2004 (Table 5). Aquatic Control Inc. completed the treatments from 1999 through 2004. Eurasian watermilfoil returned to the treated areas every year, but it appeared to be less dense. The 2004 Tier II plant sampling indicated the presence of Eurasian watermilfoil within the treatment areas, but the rake scores never were greater the 1 (1-20%). The Rock Lake Conservation Club is currently in the second year of a three-year contract for treatment of the 7.5 acres of Eurasian watermilfoil.

Table 5. Rock Lake Treatment History

Year	Treatment Activity
1999	7.5 acres of Eurasian watermilfoil treated with 2,4-D and .5 acres of emergents treated for boat lane
2000	7.5 acres of Eurasian watermilfoil treated with 2,4-D and .5 acres of emergents treated for boat lane
2001	No Treatment
2002	7.5 acres of Eurasian watermilfoil treated with 2,4-D and .5 acres of emergents treated for boat lane
2003	7.5 acres of Eurasian watermilfoil treated with 2,4-D, emergent treatment denied by IDNR
2004	7.5 acres of Eurasian watermilfoil treated with 2,4-D

Aquatic Plant Management Alternatives

The main nuisance aquatic vegetation within Rock Lake is the exotic species Eurasian watermilfoil. It is believed that Eurasian watermilfoil was first introduced from Eurasia or North Africa to an area near Maryland around 1942, possibly through the aquarium trade. Some reports suggest that this species may have been introduced into North America as early as the late 1800's through shipping ballast (Ditomaso & Healy, 2003). This species has now spread throughout the majority of North America and is the primary nuisance submersed aquatic species in Indiana. Once established, growth and physiological characteristics of Eurasian watermilfoil enable it to form a surface canopy and develop into immense stands of weedy vegetation, out competing most submersed species and displacing the native plant community (Madsen et al., 1988).

It is obvious that steps need to be taken in order to prevent Eurasian watermilfoil from reaching these dense levels. District fisheries biologist Ed Braun's primary recommendation in his 1997 Rock Lake Fish Survey Report was to develop a vegetation management plan for Rock Lake that will eliminate or at least limit Eurasian watermilfoil and promote native plant species. The Rock Lake Conservation Club was able to raise enough funds to limit Eurasian watermilfoil growth in developed areas, but additional funding is needed to attempt to eliminate this species from Rock Lake. In order to develop a scientifically sound and effective action plan for control of Eurasian watermilfoil, all aquatic management alternatives need to be considered. The alternatives that will be discussed include: no action; environmental manipulation; chemical, mechanical, or biological control methods; and any combination of these methods.

A number of different techniques have been successfully used to control Eurasian watermilfoil. These techniques vary in terms of their efficacy, rapidity, and selectivity, as well as the thoroughness and longevity of control they are capable of achieving. Each technique has advantages and disadvantages, depending on the circumstances. Selectivity is a particularly important characteristic of control techniques. Nearly all aquatic plant control techniques are at least somewhat selective, in that they affect some plant species more than others. Even techniques such as harvesting that have little selectivity within the areas to which they are applied can be used selectively, by choosing only certain areas in which to apply them. Selectivity can also occur after the fact, as when a technique controls all plants equally but some grow back more rapidly. One facet of selecting an appropriate aquatic plant control technique is matching the selectivity of the control technique with the goals of aquatic plant management. When controlling Eurasian watermilfoil, for example, it is typically desirable to use techniques that control Eurasian watermilfoil with minimal impact on most native species (Smith, 2002). A summary of the various control methods is included at the end of this section in Table 6.

No Action

What if no aquatic plant management activity took place on Rock Lake? This was the case prior to 1999 and Eurasian watermilfoil was present in dense monoculture stands (Braun, 1998), so it is feasible to believe this would be the case if no action was taken. Eurasian watermilfoil would most likely return to pre-1999 levels within 1-2 years if no management activity was initiated.

Environment manipulation

Environmental manipulation for Rock Lake would include water level draw-down. Successful use of water draw-down for controlling Eurasian watermilfoil typically requires drawing down water levels sufficiently to expose the entire Eurasian watermilfoil population. This technique can be effective if the drawdown exposes the entire Eurasian watermilfoil population to freezing and thawing, however drawdown can result in the expansion of Eurasian watermilfoil into deeper water. Drawdown can also have negative affects on native plant species.

Mechanical

Mechanical control includes cutting, dredging, or tilling the bottom sediments to eliminate aquatic plant growth. The main advantage to mechanical control is the immediate removal of the plant growth from control areas and the removal of organic matter and nutrients.

One of the most common mechanical control techniques used on larger lakes in Indiana is mechanical harvesting. Mechanical harvesting uses machines which cut plant stems and, in most cases, pick up the cut fragments for disposal. This type of mechanical control has little selectivity. Where a mix of Eurasian watermilfoil and native species exists, harvesting favors the plant species that grow back most rapidly following harvesting. In most cases, Eurasian watermilfoil recovers from harvesting much more rapidly than native plants. Thus, repeated harvesting hastens the replacement of native species by Eurasian watermilfoil and often leads to dense monocultures of Eurasian watermilfoil in frequently harvested areas. Harvesting also stirs up bottom sediments thus reducing water clarity, kills fish and many invertebrates, and hastens the spread of Eurasian watermilfoil via fragmentation. For these reasons, harvesting is not recommended as a primary Eurasian watermilfoil control method.

Individual homeowners should consider mechanical control as a method for use around their docks. There are lake rakes and other tools, which can be purchased for this activity. A lake frontage property owner can maintain a 625 square foot area (25ft. x 25ft) without obtaining a permit.

Biological

Biological controls reduce aquatic vegetation using other organisms that consume aquatic plants or cause them to become diseased (Smith, 2002). The main biological controls used in Indiana for control of Eurasian watermilfoil are the white amur (grass carp) and the milfoil weevil.

The white amur or grass carp *Ctenopharyngodon idella* is a herbivorous fish imported from Asia. Triploid grass carp, the sterile genetic derivative of the diploid grass carp, are legal for sale in Indiana. Grass carp tend to produce all or nothing aquatic plant control. It is very difficult to achieve a stocking rate sufficient to selectively control nuisance species without eliminating all submersed vegetation. Grass carp are not particularly appropriate for Eurasian watermilfoil control because Eurasian watermilfoil is low on their feeding preference list; thus, they eat most native plants before consuming Eurasian watermilfoil (Smith, 2002). Once grass carp are introduced into a lake they are virtually impossible to remove. Grass carp are not recommended for Eurasian watermilfoil control.

The milfoil weevil, *Euhrychiopsis lecontei*, is a native North American insect that consumes Eurasian and Northern watermilfoil. The weevil was discovered following a natural decline of Eurasian watermilfoil in Brownignton Pond, Vermont (Creed and Sheldon, 1993), and has apparently caused declines in several other water bodies. Weevil larvae burrow in the stem of Eurasian watermilfoil and consume the vascular tissue thus interrupting the flow of sugars and other materials between the upper and lower parts of the plant. Holes where the larvae burrow into and out of the stem allow disease organisms a foothold in the plants and allow gases to escape from the stem, causing the plants to lose buoyancy and sink (Creed et al. 1992).

Concerns about the use of the weevil as a biological control agent relate to whether introductions of the milfoil weevil will reliably produce reductions in Eurasian watermilfoil and whether the resulting reductions will be sufficient to satisfy users of the lake (Smith, 2002). Following our research, no conclusive data concerning the role of weevils in reducing Eurasian watermilfoil populations has been made available. In 2003, Scribailo & Alix conducted a weevil release study on three Indiana lakes and had no conclusive evidence supporting the use of weevils in reducing milfoil populations. Weevils may reduce milfoil populations in some lakes, but predicting which lakes and how much, if any, control will be achieved has not been documented.

Chemical Control
Chemical control uses chemical herbicides to reduce or eliminate aquatic plant growth. The main advantage of using herbicides is their overall effectiveness. The publics main concern over herbicide use is safety. This should not be a concern due to the extensive testing which is required prior to herbicide being approved for use in the aquatic environment. These tests ensure that the herbicides are low in toxicity to human and animal life and they are not overly persistent or bioaccumulated in fish or other organisms.

There are two different types of aquatic herbicides; systemic and contact. Systemic herbicides are translocated throughout the plants and thereby kill entire plants. Fluridone (trade name Sonar & Avast!), 2,4-D (trade name Navigate, Aqua-Kleen, & DMA4 IVM), and trichlopyr (trade name Renovate) are systemic herbicides that can effectively control Eurasian watermilfoil.

Based upon the author's experience and personal communication with a vast array of North American aquatic plant managers, whole-lake fluridone applications are by far the most effective means of controlling Eurasian watermilfoil. Successful fluridone treatments yield a dramatic reduction in the abundance of Eurasian watermilfoil, often reducing it to the point that Eurasian watermilfoil plants are difficult to detect following treatment (Smith, 2002). An advantage to using fluridone over most contact herbicides is its selectivity. Most strains of Eurasian watermilfoil have a lower tolerance to fluridone than the majority of native species, so if the proper rates are applied Eurasian watermilfoil can be controlled with little harm to native populations.

Triclopyr is a systemic herbicide that has recently been approved for use in aquatics. Triclopyr typically is used for treating isolated milfoil beds as opposed to whole lake treatments. Trichlopyr is very selective to Eurasian watermilfoil. A study was recently completed which focused on the effects of triclopyr on Eurasian watermilfoil and native vegetation. The researchers found Eurasian watermilfoil biomass was reduced by 99% in treated areas at 4 weeks post-treatment, remained low one year later, and was still at acceptable levels of control at two years post-treatment. Non-target native plant biomass increased 500-1000% by one year post-treatment, and remained significantly higher in the cove plot at two years post-treatment. Native species diversity doubled following herbicide treatment, and the restoration of the community delayed the re-establishment and dominance of Eurasian watermilfoil for three growing season (Getsinger et. al., 1997). Triclopyr is a good alternative to fluridone when Eurasian watermilfoil is not abundant throughout an entire water body.

Applied properly, 2,4-D can also yield major reductions in the abundance of Eurasian watermilfoil, but long-term reductions are more difficult to achieve using 2,4-D than using whole-lake fluridone applications. Treatments must be even and dose rates accurate. Under the best circumstances, some areas will probably need to be treated repeatedly before the Eurasian watermilfoil in them is controlled. Also, the difficulty of finding and treating areas of sparse Eurasian watermilfoil makes it likely that Eurasian watermilfoil will be reestablished from plants surviving in these areas (Smith 2002). This formulation should be used much like Triclopyr, but the same results may not be achieved. Unlike Triclopyr, 2,4-D can also impact the native species coontail. Aquatic Control has used 2,4-D on Rock Lake since 1999 with the exception of 2001 and the results have been good in the treatment areas. However, it has been necessary to apply 2,4-D every season in order to control Eurasian watermilfoil in this area, and as seen by the plant sampling, Eurasian watermilfoil is still present in the treatment area.

Contact herbicides can also be effective for controlling submersed vegetation in the short term. The three primary contact herbicides used for control of submersed vegetation are diquat (trade name Reward), endothal (trade name Aquathol), and copper based formulations (trade names Komeen, Nautique, and Clearigate).

Historically, a drawback to the use of contact herbicides has been the lack of selectivity exhibited by these herbicides. However, a study recently completed by Skogerboe and Getsinger outlines how endothal can be used for control of the exotic species curlyleaf pondweed and Eurasian watermilfoil with little effect on the majority of native species. They found early season treatments with endothall effectively controlled Eurasian watermilfoil and curlyleaf pondweed at several application rates with no regrowth eight weeks after treatment. Sago pondweed, eel grass, and Illinois pondweed biomass wee also significantly reduced following the endothall application, but regrwoth was observed at eight weeks post-treatment. Coontail and elodea showed no effects from endothall at three of the lower application rates. Spatterdock, pickerelweed, cattail, and smartweed were not injured at any of the application rates (Skogerboe & Getsinger 2002). This type of treatment strategy could be applied to lakes that have large areas of both curlyleaf pondweed and Eurasian watermilfoil. Endothal could also be effective the year after whole lake fluridone treatments where curlyleaf pondweed typically returns the following season.

Diquat and many copper formulations are effective fast acting contact herbicides. These formulations are typically used when control of all submersed vegetation is desired. Aquatic Control uses these herbicides for control of nuisance vegetation around docks and near-shore high-use areas. These herbicides are not selective and plants can often times recover in 4-8 weeks after treatment.

Table 6. Summary of potential vegetation control methods for Rock Lake.

Control Method	Advantages	Disadvantages	Conclusion
No Action	No cost and less controversy	No plant control, degradation of fish habitat, difficult boating, and spread of exotic plant species.	Something should be initiated to prevent spread of milfoil and reduce nuisance conditions.
Environmental Manipulation (drawdown)	Low cost, compaction of flocculent sediments, may get control of some nuisance species, and less controversial.	Unpredictable plant control, exposes desirable plants and animals to freezing and thawing, dependent on good freeze, could impede recreation, dependent on spring rains to raise water level or lack of precipitation in winter to lower water level.	Not possible to sufficiently lower lake and may damage beneficial natives.
Mechanical (cutting, dredging, or tilling)	Low cost, less controversy, can target areas of desired control, removes organics.	Possibility of spreading exotic vegetation, labor intensive, damage to fish and other aquatic organisms, and harvesting can promote increased milfoil growth.	Not good option due to potential spread of exotics. Could possibly be used on small-scale initial infestation or post-treatment.
Biological Control (milfoil weevil)	No chemical needed, naturally occurring native species, no use restrictions following application, selective for Eurasian watermilfoil, and known to cause fatal damage to plant	Studies have been inconclusive on the effectiveness and cost is relatively high compared to most other control methods.	No proof that this method is effective. Too large of an investment for unproven method.
Biological Control (Grass Carp)	No chemical needed, no use restrictions following application, no reproduction, and proven to consume aquatic vegetation.	Prefers many of the native species over exotic species, non-native fish species, tend to move downstream, once they are introduced they are nearly impossible to remove.	Not a good option due to inability to remove once stocked and preference for native vegetation.
Chemical Control	Proven safe and effective technique, can be selective, relatively easy application, and fast results.	Higher cost than most techniques, public concern over chemicals, build-up of dead plant material following application, and lake use restrictions	Proven to be effective with minimal use restrictions very effective Eurasian watermilfoil control

Action Plan

Vegetation management activities have taken place on Rock Lake since at least 1999. Management activities began following the recommendation of district fisheries biologist Ed Braun. This activity included the treatment of Eurasian watermilfoil with 2,4-D herbicide every year except 2001. This treatment was limited to a 7.5 acre area, which was located near the developed shoreline areas (see Figure 3 in Aquatic Plant Community section). This treatment area was limited due to the budget of the Rock Lake Conservation Club. Spatterdock and white water lily were treated in 1999, 2000, and 2002. This treatment was limited to a boat lane leading into Chippewanuck Creek and was not permitted by the Department of Natural Resources after 2002.

The 2004 sampling discovered Eurasian watermilfoil at 27.5% of sites. The density of milfoil never exceeded a rake score of 1. The low density is most likely due to the 2004 treatment. The majority of the sites where Eurasian watermilfoil was present were located in the southeast and eastern sections of the lake (see Figure 8 in Aquatic Plant Community section). Eurasian watermilfoil was rarely sampled in the western and northern part of the lake where spatterdock and white water lily beds dominated. Due to the relatively small area where Eurasian watermilfoil was present, it is our recommendation that Triclopyr herbicide be used in 2005 in an attempt to eradicate milfoil from the lake. Typically, whole-lake Sonar treatments are most effective at eliminating this species, however milfoil was only found in one distinct area of the lake thus reducing the need for a whole-lake treatment. Tier I and Tier II sampling should take place prior to treatment in order to correctly identify the sites that will be treated. Triclopyr should be applied to all areas where Eurasian watermilfoil is discovered. Treatment should be scheduled for late May of 2005. The tricolpyr treatment will be more effective than the 2-4,D treatment and will not harm the native coontail population. This treatment should not be limited to the 7.5 acres which has been treated in the past. The treatment should be evaluated every season by completing Tier II plant sampling in July. If Eurasian watermilfoil continues to return, the strategy should be reevaluated and a whole lake fluridone treatment should be considered. An cost estimate of this treatment strategy is laid out in Table 7.

Table 7. Budget estimates for management options

	2005	2006	2007
Herbicide & Application Cost*	$5,000	$3,500	$2,000
Vegetation Sampling & Plan Update	$1,070	$1,070	$1,070
Total:	**$6,070**	**$4,570**	**$3,070**

*Cost is figured on treating 12.5 acres of Eurasian watermilfoil in 2005. This is theoretical and based on past visual inspections. Actual acreage to be determined following spring survey.

It has been brought to our attention that there are two ponds upstream of Rock Lake which may also contain Eurasian watermilfoil. Steps should be taken to investigate these bodies of water for the presence of Eurasian watermilfoil. These bodies of water may be a source of reintroduction.

This treatment strategy most likely will lead to an increase in native vegetation. This native vegetation may reach nuisance levels in developed areas. Homeowner's should be educated on their options for controlling nuisance vegetation in a 625 square foot area. This may include small doses of granular contact herbicide or mechanical removal.

Property owners' have raised concern over the spread of white water lily and spatterdock throughout the lake. These species currently are not at nuisance levels and are providing good fish habitat for Rock Lake. The boat lane in the northern end of the lake was open and water lilies and spatterdock are not restricting navigation. If the spatterdock and lilies continue to fill in the boat lane it should be permitted to apply herbicide in order to keep the lane open. Residents should use mechanical harvest or chemical application to control these species in the legal 625 square foot area allowed by law. Mechanical harvest (pulling up the plant or digging up the roots) can be effective, but may be too labor intensive for some residents. Imazapyr (trade name Habitat), glyphosate (trade name Aqua-Pro & Rodeo), Triclopyr (trade name Renovate), and 2,4-D (trade name Aqua-Kleen, Navigate, & DMA 4IVM) applied properly can control these species. The liquid formulations must be misted on the plants in order to gain control. A surfactant should be added to this mixture. In most cases a 1% solution (1.5 oz. Per Gal) is effective. Granular 2,4-D can also be used at a rate of 200 pounds per acre or 10 pounds per 2000 square feet.

If the action plan is initiated a noticeable reduction and possible elimination of Eurasian watermilfoil should occur in one to three years. In response to the reduction in Eurasian watermilfoil, an increase in native species abundance should take place.

Education

It is important that all lake users, lake residents, and other stakeholders participate and be informed about the lake management activities. A meeting was conducted in February of 2005 in order to discuss the draft management plan and obtain user input. A second meeting should also be scheduled to discuss the final management plan. Each winter a meeting should take place to discuss necessary changes in the plan and to update lake users of changes and activities. Mailings, informing residents of plant management activities, should be distributed to all concerned parties. Additional information concerning aquatic vegetation management can be obtained at the following web sites: www.mamps.org; www.aquatic.org; www.apms.org; www.aquaticcontrol.com; and www.nalms.org .

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Appendix A. Macrophyte List for Rock Lake

Common Name	Scientific Name	Tier I Survey	Tier II Survey
American Water Willow	*Justica americana*	X	
Coontail	*Ceratophyllum demersum*	X	X
Eurasian Watermilfoil	*Myriophyllum spicatum*	X	X
Sago Pondweed	*Potamogeton pectinatus*	X	X
Spatterdock	*Nuphar variegetum*	X	X
White Water Lily	*Nymphaea tuberosa*	X	X

American Water Willow (*Justica americana*)is a perennial herb, spreading by rhizomes and sometimes forming large colonies. Stems are usually unbranched and smooth. Leaves are opposite, linear to lance-shaped, and tapered to a tip. Inhabits shallow water, muddy pond and lakeshores, and mud bars[2]. Considered good fish cover, especially for largemouth bass.

Coontail (*Ceratophylum demersum*) is a commonly occurring aquatic plant in the Midwest in neutral to alkaline waters[1]. It is a submersed dicot with coarsely toothed leaves whorled about the stem[2]. This plant is given its name due to its resemblance to the tail of a raccoon. Coontail has been found to be an important food source for wildfowl as well as a good shelter for small animals[2]. This plant is also a good shelter for young fish, and support of insects[2], but has been known to crowd out other species of aquatic plants[3].

Eurasian watermilfoil (*Myriophyllum spicatum*) is an exotic aquatic plant that has been known to crowd out native species of plants. This species spreads quickly because it can grow from very small plant fragments and survive in low light and nutrient conditions[3]. This dicot has stems that typically grow to the water surface and branch out forming a canopy that shades other species of aquatic plants. Eurasian water-milfoil has characteristic red to pink flowering spikes that protrude from the water surface one to two inches high[1]. The segmented leaves grow in whorls of three to four around the stem[1]. This exotic plant is easily differentiated from its native relative, northern milfoil, by stem growth and the numbers of

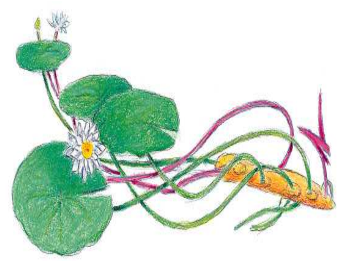
[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.
[2] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.
[3] Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

sections per leaf.

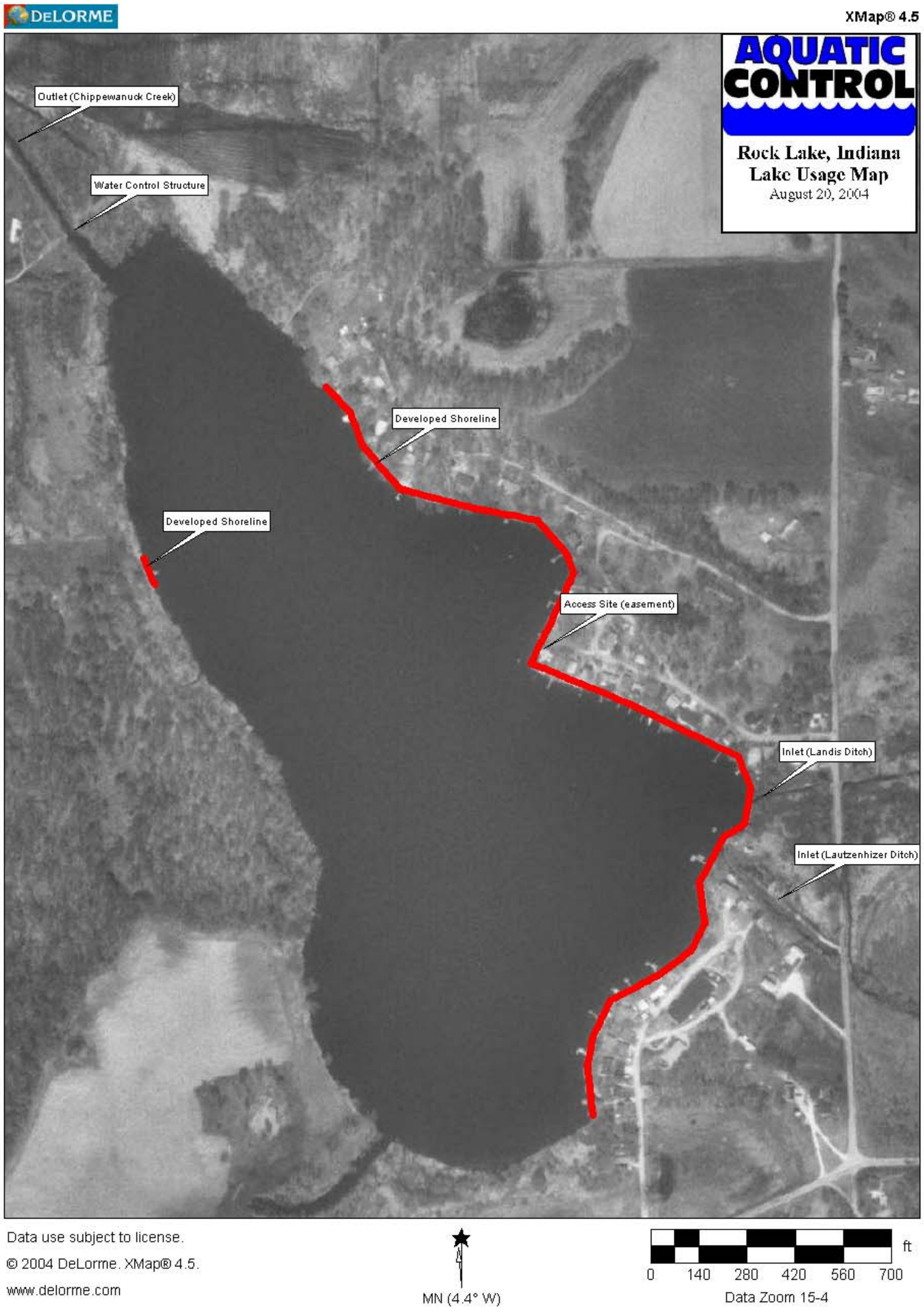
Sago pondweed (*Stuckenia pectinata*) is a submersed monocot with leaves that are threadlike to narrowly linear that form a sheath around the stem[1]. The nutlet and tubers of this plant make it the most important pondweed for ducks[2]. It also provides food and shelter for young trout and other fish[2]. This species can produce thick nuisance growth in shallow near-shore areas of lakes.

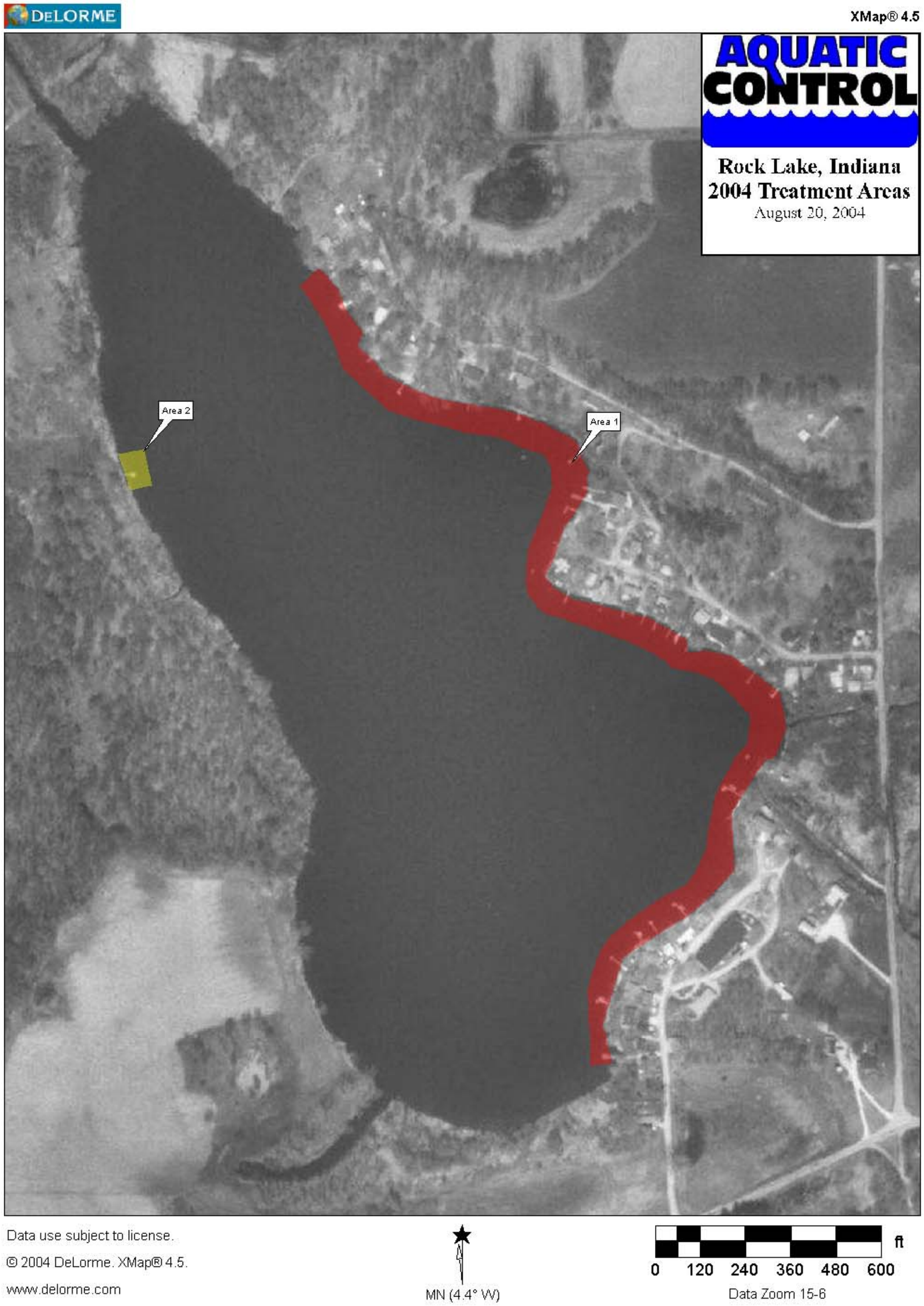
Yellow pond lily (*Nuphar variegetum*) is an emergent dicot with broad, deeply lobed leaves emerging from the water[1]. This plant has distinctive large yellow flowers emanating from spikes. Yellow pond lily produces seeds and rootstocks that are used by wildfowl, beaver, moose and porcupine[2]. This plant attracts wildfowl and marsh birds and the bases of the petioles are eaten by muskrats[2]. Yellow pond lilies are a poor producer of food for fish, but provide good shade and shelter[2].

White water lily (*Nymphaea odorata*) is a floating attached dicot that grows from tubers and produces broad, deeply lobed floating leaves and white flowers[1]. This plant produces seed that is fair food for wildfowl[2]. The root stocks and petiole bases are eaten by muskrats and the "roots" are eaten by beaver, deer, moose, and porcupine[2]. White water lilies can provide good habitat for fish, but can induce a negative value when too dense[2]



Appendix B. Maps

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AQUATIC CONTROL
Rock Lake, Indiana
2004 Treatment Areas
August 20, 2004
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Area 1
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www.delorme.com
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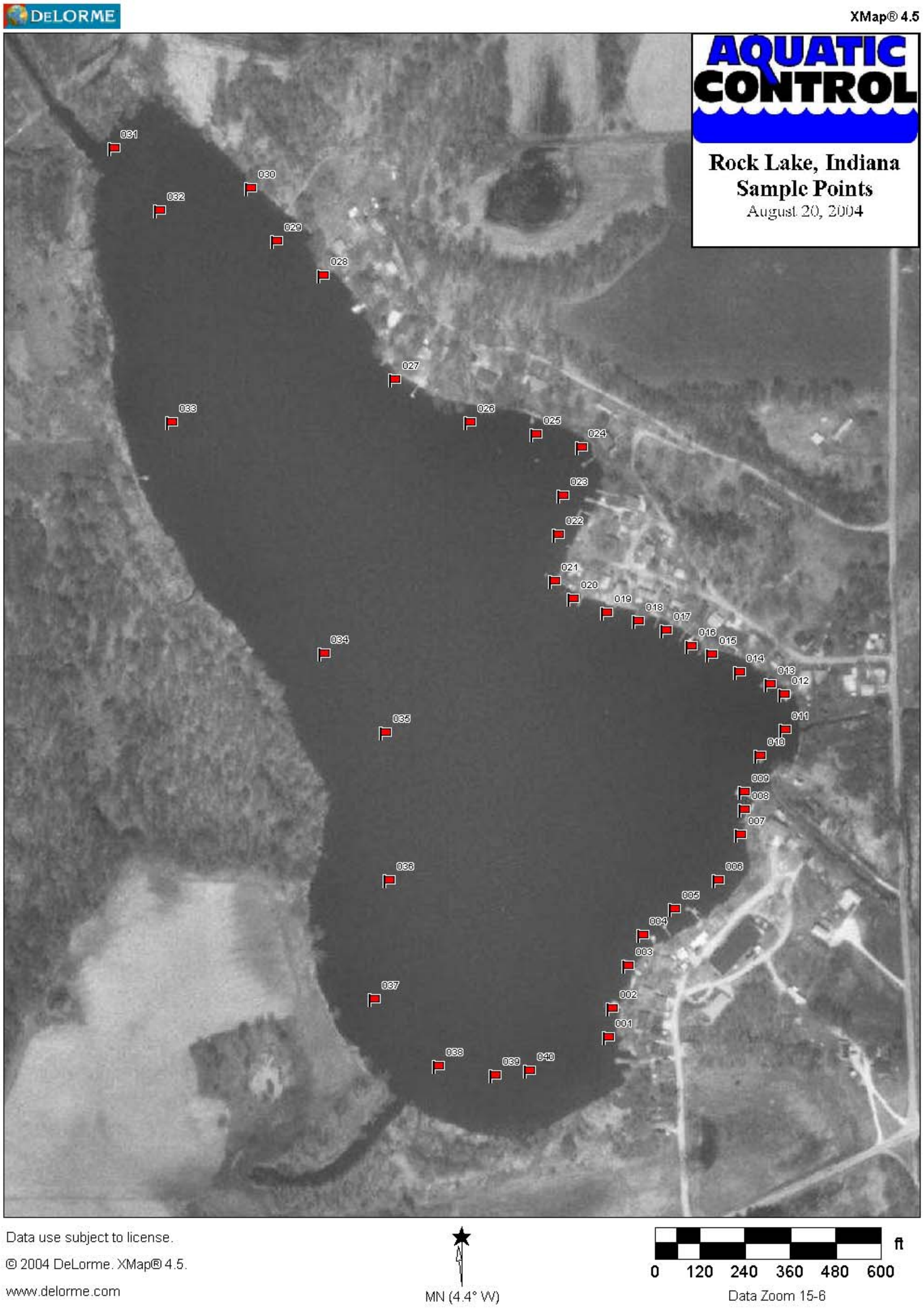
Data Zoom 15-6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Rock Lake, Indiana
Sample Points
August 20, 2004
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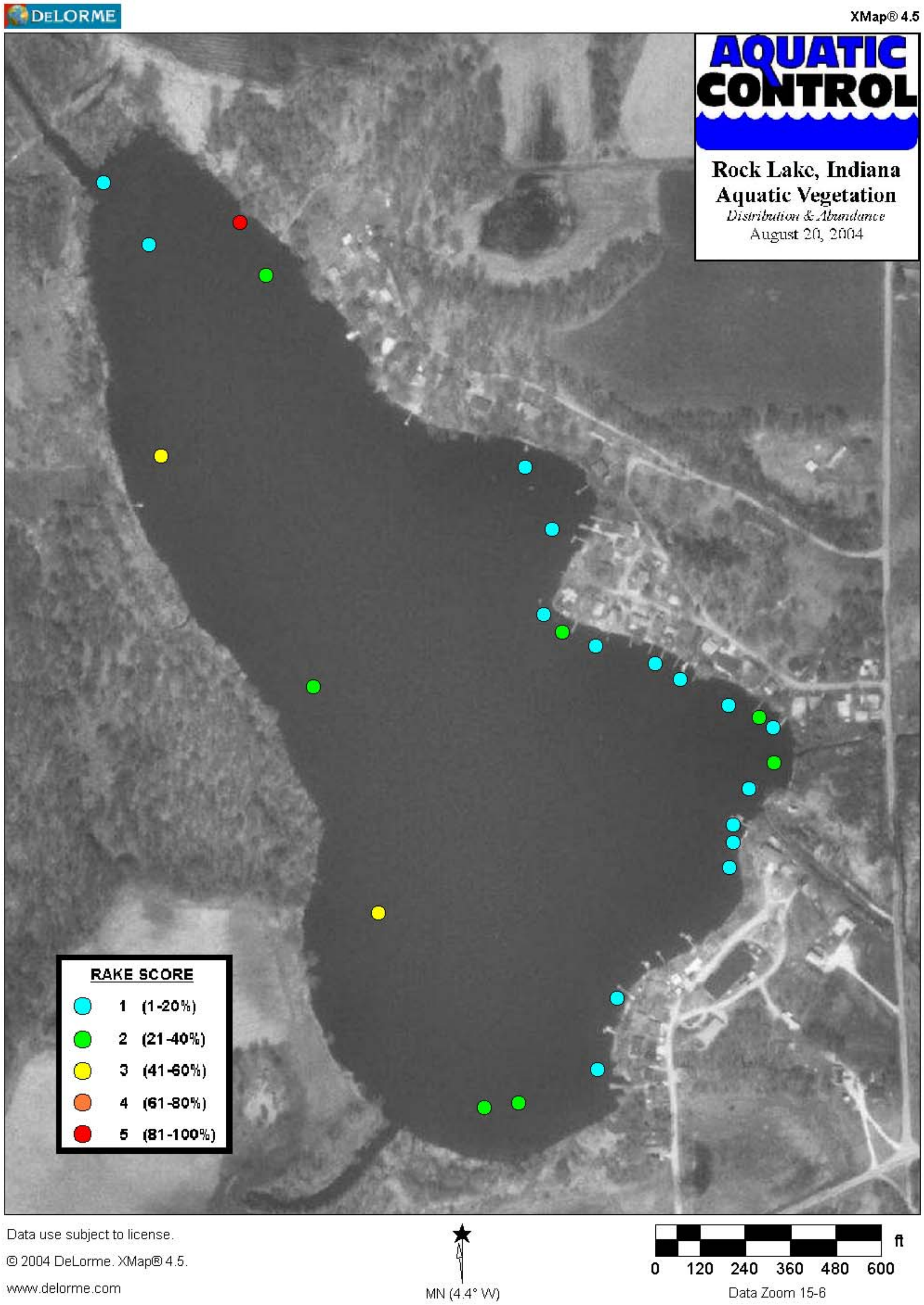
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Aquatic Vegetation
Distribution & Abundance
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2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
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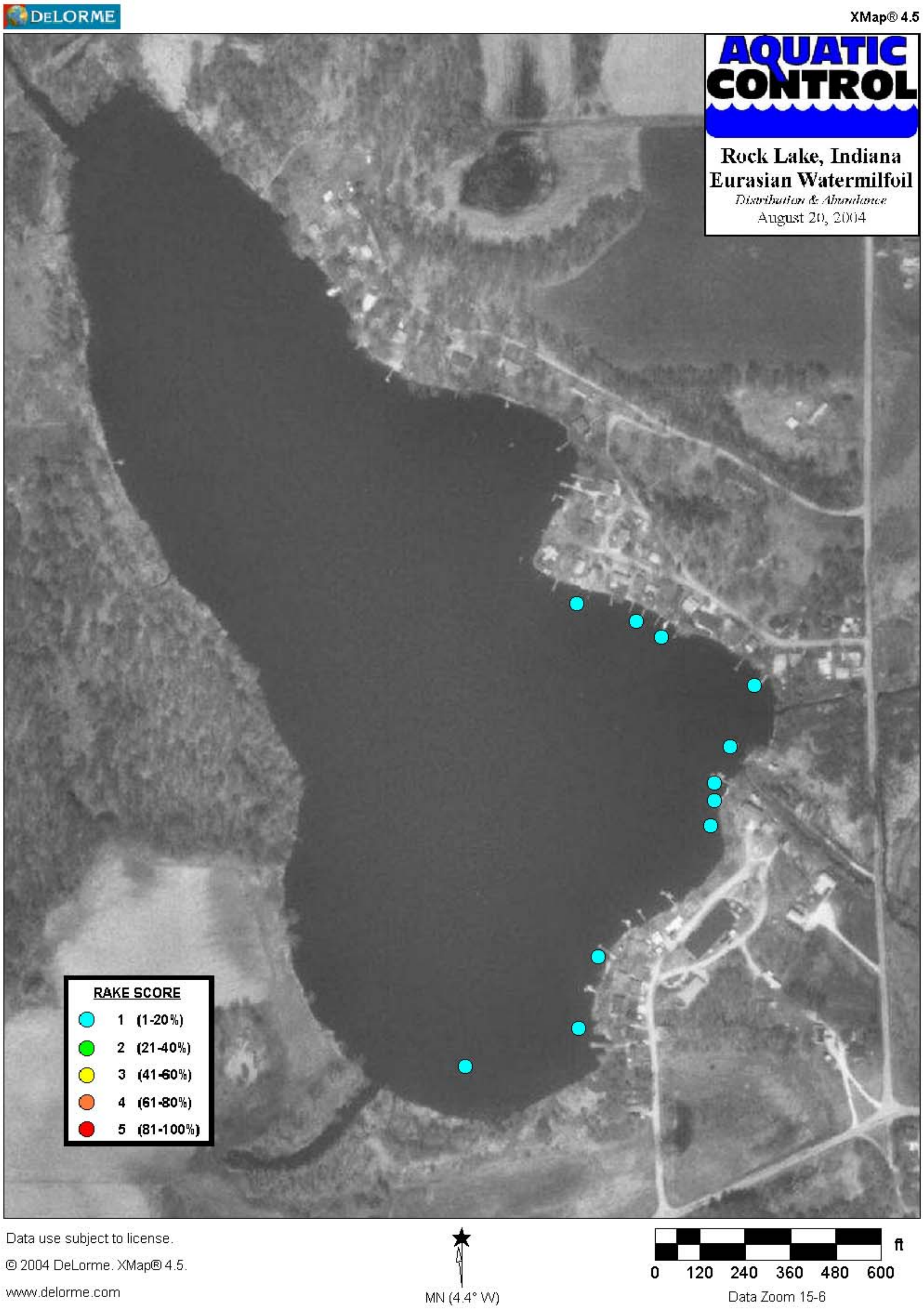
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Eurasian Watermilfoil
Distribution & Abundance
August 20, 2004
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2 (21-40%)
3 (41-60%)
4 (61-80%)
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www.delorme.com
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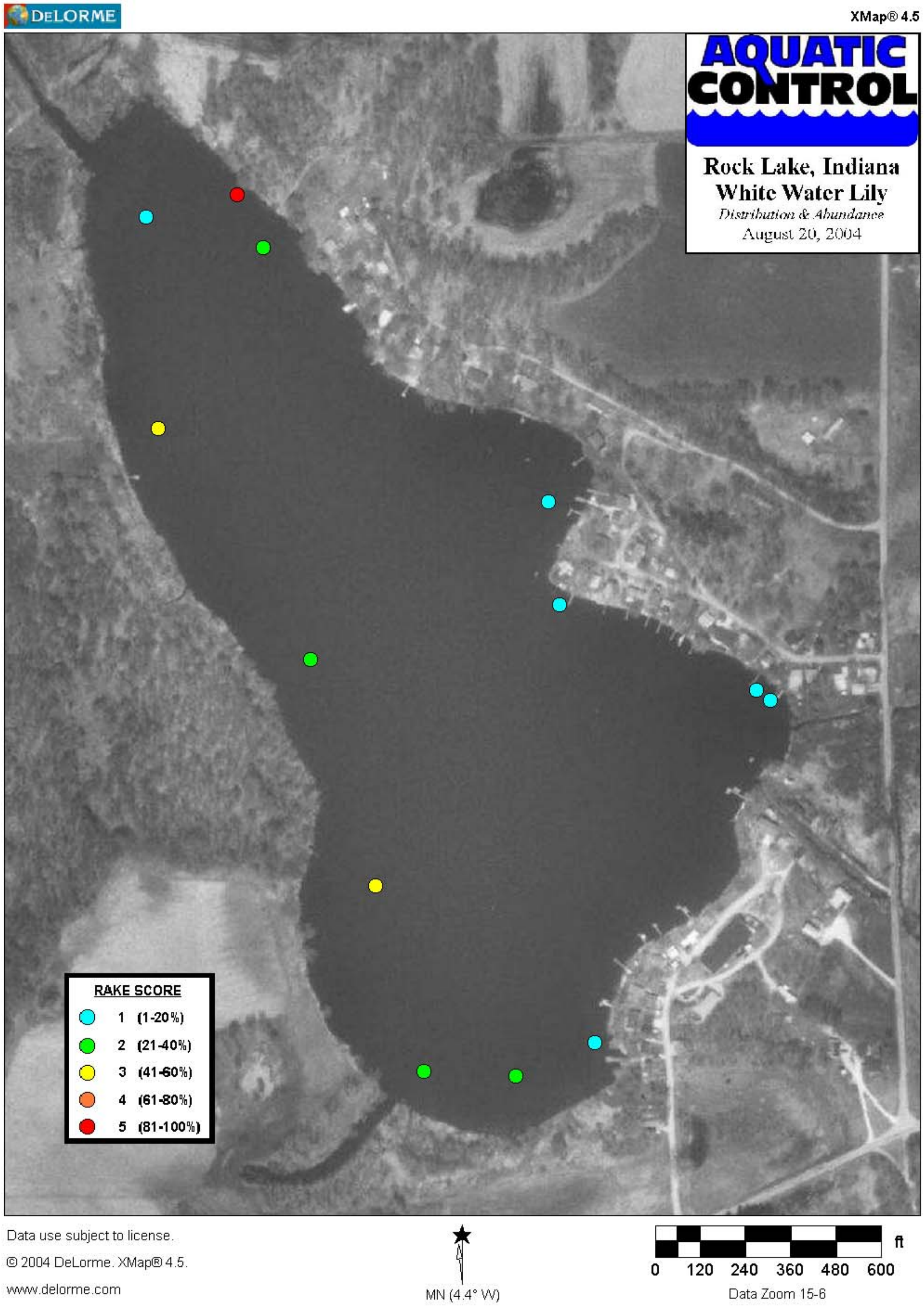
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Rock Lake, Indiana
White Water Lily
Distribution & Abundance
August 20, 2004
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2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
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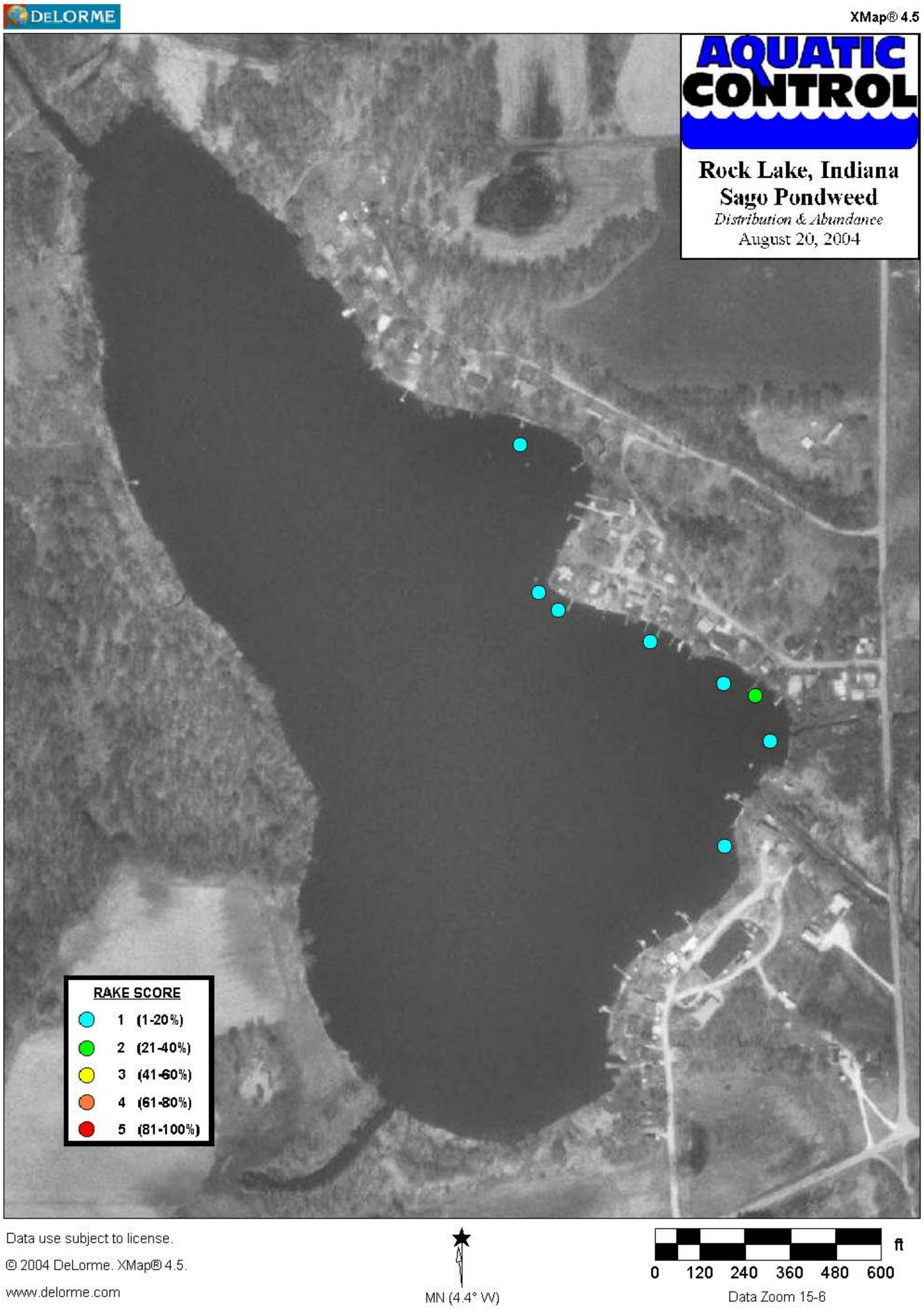
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Rock Lake, Indiana
Sago Pondweed
Distribution & Abundance
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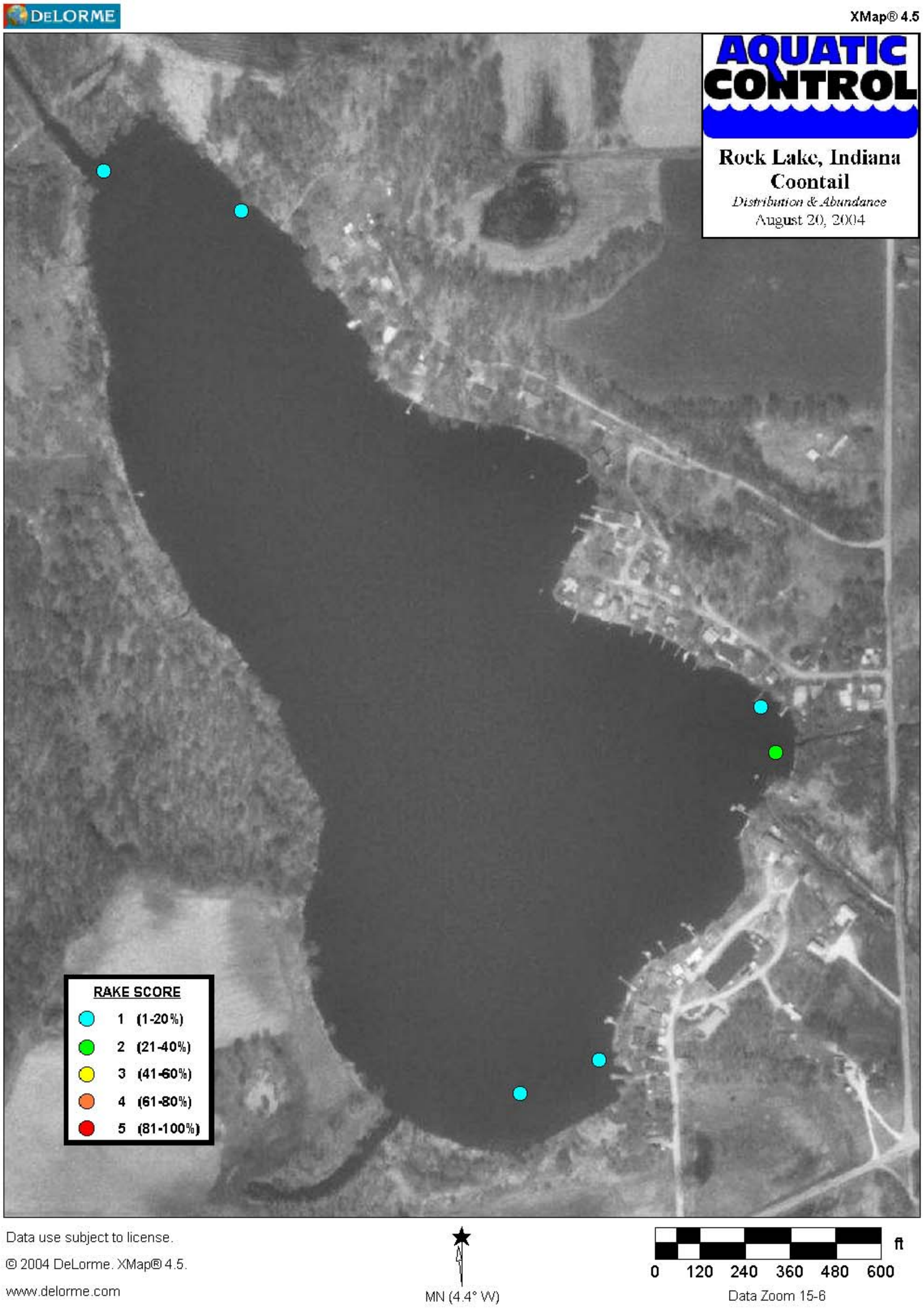
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Rock Lake, Indiana
Coontail
Distribution & Abundance
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Data Zoom 15-6

Appendix C. Tier II Survey Data

Lake	Date	Latitude	Longitude	Site	Depth	RAKE	MYSP2	CEDE4	POPE6	NULU	NYTU	ALGA	SpeNum	NatSpeNum
Rock	8/20/04	41.03941	-85.97735	1	1.0	1	1	1			1		3	2
Rock	8/20/04	41.03962	-85.97732	2	2.0								0	0
Rock	8/20/04	41.03993	-85.97717	3	2.0	1	1						1	0
Rock	8/20/04	41.04016	-85.97702	4	2.0								0	0
Rock	8/20/04	41.04034	-85.97672	5	5.0								0	0
Rock	8/20/04	41.04055	-85.9763	6	2.0								0	0
Rock	8/20/04	41.04088	-85.97609	7	1.0	1	1		1				2	1
Rock	8/20/04	41.04106	-85.97605	8	2.0	1	1						1	0
Rock	8/20/04	41.04119	-85.97605	9	2.0	1	1						1	0
Rock	8/20/04	41.04145	-85.9759	10	2.0	1	1						1	0
Rock	8/20/04	41.04164	-85.97566	11	2.0	2		2	1				2	2
Rock	8/20/04	41.0419	-85.97567	12	3.0	1	1				1		2	1
Rock	8/20/04	41.04197	-85.9758	13	3.0	2		1	2		1		3	3
Rock	8/20/04	41.04206	-85.9761	14	3.0	1			1				1	1
Rock	8/20/04	41.04218	-85.97637	15	2.0								0	0
Rock	8/20/04	41.04225	-85.97656	16	3.0	1	1						1	0
Rock	8/20/04	41.04236	-85.9768	17	2.0	1	1		1				2	1
Rock	8/20/04	41.04243	-85.97707	18	2.0								0	0
Rock	8/20/04	41.04249	-85.97737	19	2.0	1	1						1	0
Rock	8/20/04	41.04259	-85.97769	20	2.0	2			1		1		2	2
Rock	8/20/04	41.04271	-85.97787	21	2.0	1			1				1	1
Rock	8/20/04	41.04305	-85.97783	22	3.0								0	0
Rock	8/20/04	41.04333	-85.97779	23	3.0	1					1		1	1
Rock	8/20/04	41.04368	-85.97761	24	3.0								0	0
Rock	8/20/04	41.04378	-85.97805	25	4.0	1			1				1	1
Rock	8/20/04	41.04387	-85.97868	26	5.0								0	0
Rock	8/20/04	41.04417	-85.9794	27	3.0								0	0
Rock	8/20/04	41.04492	-85.98008	28	4.0								0	0
Rock	8/20/04	41.04517	-85.98053	29	3.0	2					2		1	1
Rock	8/20/04	41.04556	-85.98078	30	2.0	5		1			5	1	2	2
Rock	8/20/04	41.04585	-85.98209	31	3.0	1		1				1	1	1
Rock	8/20/04	41.04539	-85.98165	32	3.0	1					1		1	1
Rock	8/20/04	41.04386	-85.98153	33	3.0	3					3		1	1
Rock	8/20/04	41.04219	-85.98007	34	4.0	2					2		1	1
Rock	8/20/04	41.04162	-85.97949	35	4.0								0	0
Rock	8/20/04	41.04055	-85.97945	36	3.0	3					3		1	1
Rock	8/20/04	41.03969	-85.97959	37	3.0								0	0
Rock	8/20/04	41.03921	-85.97898	38	2.0						2		1	1
Rock	8/20/04	41.03914	-85.97844	39	3.0	2	1			2			2	1
Rock	8/20/04	41.03917	-85.9781	40	4.0	2		1			2		2	2

Species Codes	
BIBE	Bur marigold
CEDE4	Coontail
CH?AR	Chara
ELCA7	Elodea
LEMN	Duckweeds
MYHE	Broadleaf watermilfoil
MYSI	Northern watermilfoil
MYSP2	Eurasian watermilfoil
MYVE	Whorled watermilfoil
NAFL	Slender naiad
NAGU	Southern waternymph
NAMA	Spiny naiad
NAMI	Brittle waternymph
NELU	American lotus
NI?TE	Nitella
NOAQVG	No aquatic vegetation
NULU	Yellow pond lily
NYTU	White water lily
POAM	Large-leaf pondweed
POCR3	Curly-leaf pondweed
POFO3	Leafy pondweed
POGR8	Variable pondweed
POIL	Illinois pondweed
PONO2	American pondweed
POPE6	Sago pondweed
POPR5	White-stemmed pondweed
POPU7	Small pondweed
PORI2	Richardson's pondweed
POZO	Flat-stemmed pondweed
UTMA	Common bladderwort
VAAM3	Wild celery, eel grass
WO?LF	Watermeal
ZAPA	Horned pondweed
ZODU	Water stargrass
Count	34